

Compartment Fire Experiments for Field Model Development

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Background/Motivation

- **Field modeling of fires needs improvement for underventilated fire conditions to better predict the radiative environment, burning rate, toxic gas production, etc.**
- **Complete and accurate data are required for chemistry submodel development and improvement**
- **Flashed-over enclosure fire dynamics and the sensitivity to fuel type, fuel distribution, ventilation, etc. have not been fully investigated or characterized**

Objectives

- **To improve and apply experimental measurements to accurately characterize the environment in underventilated enclosure fires,**
- **To provide the understanding of fire chemistry required to guide the development of chemistry sub-models for field models, and**
- **To validate model predictions for underventilated burning in an enclosure.**

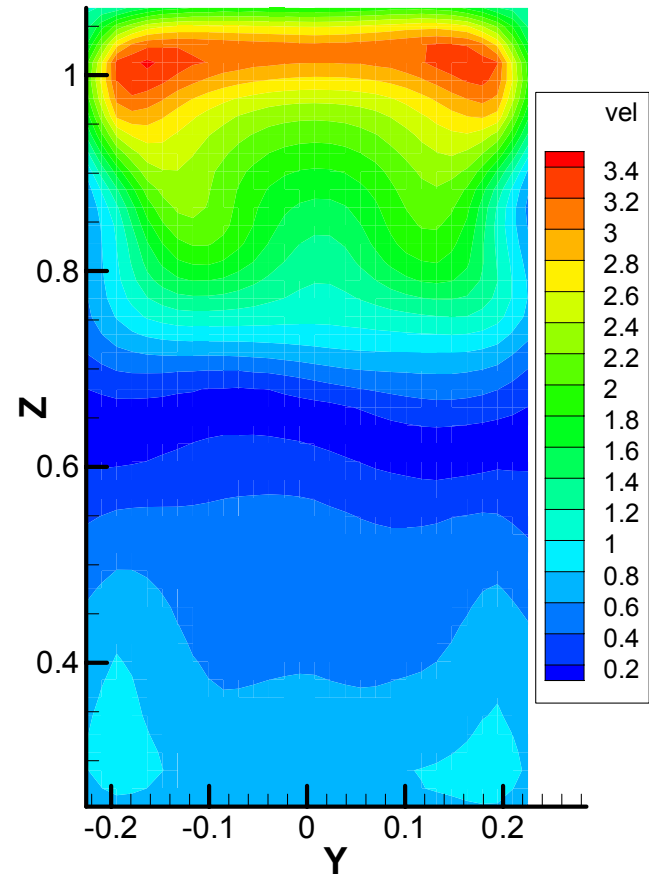
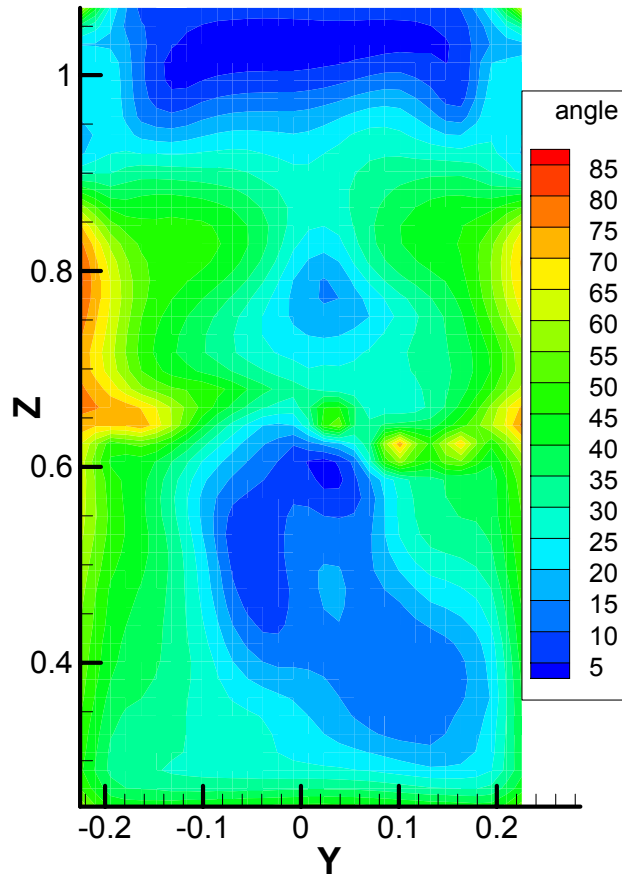
Approach

- Use FDS model predictions to aid design
- Conduct initial experiments in 2/5-scale enclosure (RSE)
- Use well-controlled burners
- Vary ventilation
- For initial natural gas experiments, follow previous measurement locations
- Run experiments to near-steady conditions

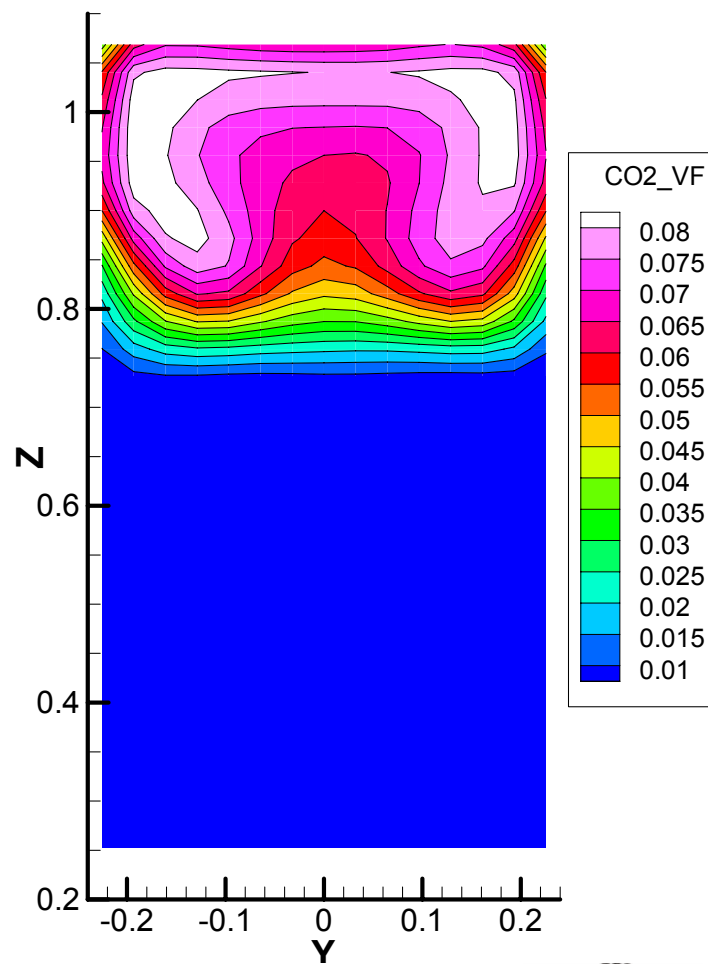
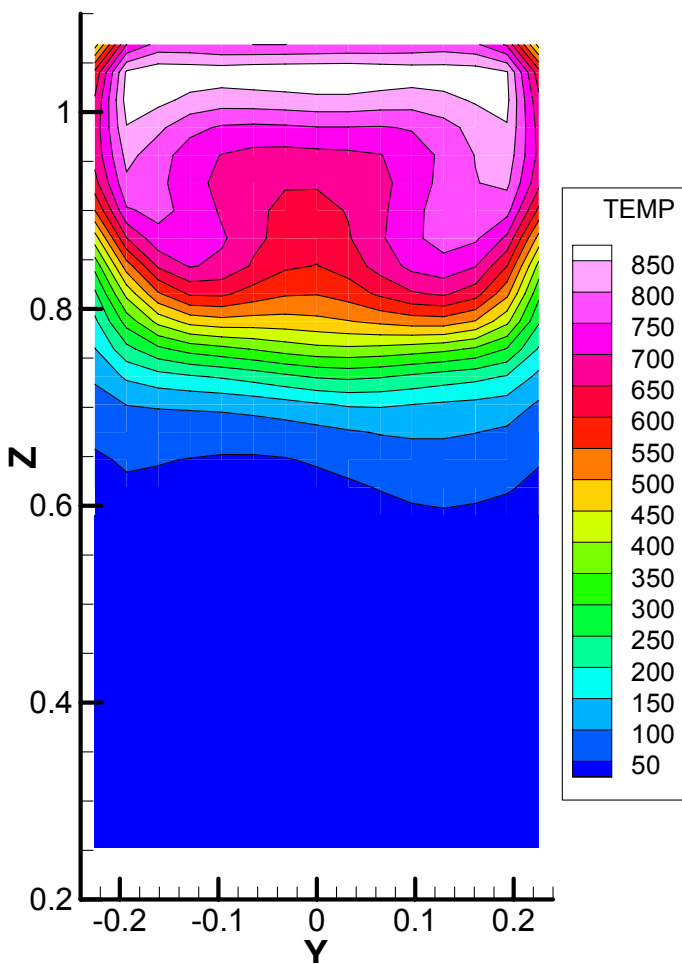
Approach (cont'd)

- Apply total hydrocarbon, gravimetric soot, gas chromatography measurements
- Conduct mapping measurements (T, V, species) of the doorway under steady conditions
- Use measurements to determine:
 - Mass, enthalpy, and carbon fluxes
 - Relative amounts of internal and external burning
- Estimate uncertainties associated with each measurement
- Run replicate tests as able

200 kW Natural Fire Gas Velocity Simulation



200 kW Natural Gas Fire Temperature & CO₂ Simulation



Experimental Plan

Phase I (March 2006)

For 4 NG and heptane HRRs (75 kW, 180 kW, 270 kW, 400 kW):

- **Sample CO, CO₂, O₂, HC, GC, soot at 2 locations in the RSE**
- **Measure interior temperatures**
- **Measure doorway centerline and some horizontal velocities**
- **Measure doorway centerline and some horizontal temperatures**
- **Repeat one or more fires for repeatability**
- **Repeat some fires for half-width doorway**
- **Test interactions between aspirated thermocouples and bi-directional probes**

Experimental Plan

Phase II, Proposed (June 2006)

- **Conduct freeburn tests of NG and heptane for soot, HC, comparison**
- **Map O₂, CO, CO₂, HC, V, T, and soot in the doorway for full-width and half-width doorways**
- **Calculate mass, enthalpy, and carbon fluxes through doorway**
- **Explore replenished, natural-burning fuel**
- **Explore distributed fuel**

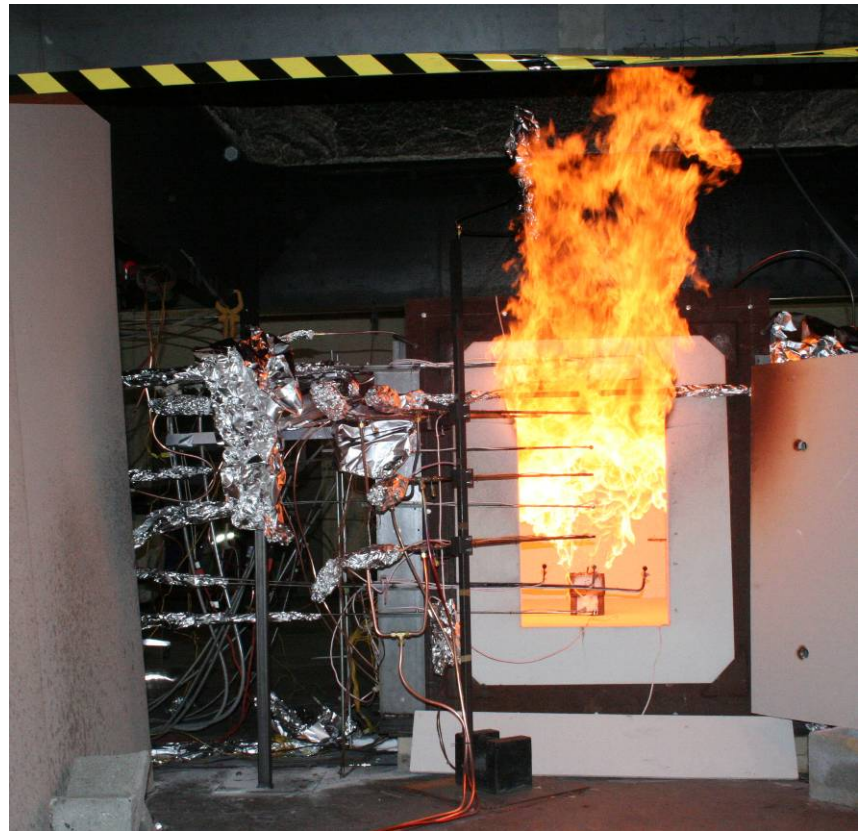
Phase I Measurements

Measurement	Locations
Extractive soot	Front & rear upper layer
CO, CO ₂ , O ₂ , total hydrocarbons	Front & rear upper layer
Gas Chromatograph	Rear upper layer
Bi-directional probes with pressure transducers	Doorway array
Gas temperatures with aspirated TCs	Front & rear upper layer, doorway array
Gas temperatures with bare-bead TCs	Front & rear upper layer, doorway array
Total heat flux	Floor in front of burner and to rear of burner
Interior wall temperatures with bare-bead TCs	Floor in front of burner, ceiling above front sampling position
Exterior wall temperatures with bare-bead TCs	Rear wall

Experimental Set-Up Photographs



Experimental Set-Up Photographs



Experimental Conditions

Condition	Fuel	Approx. Fire Size (Phi for Std. Door)	Ventilation
No. of Conditions	2	4	3
Condition 1	Natural Gas	75 kW (0.4)	Open burning
Condition 2	Heptane	180 kW (1.0)	Std. RSE config
Condition 3		270 kW (1.5)	Half-Width Door
Condition 4		400 kW (2.2)	

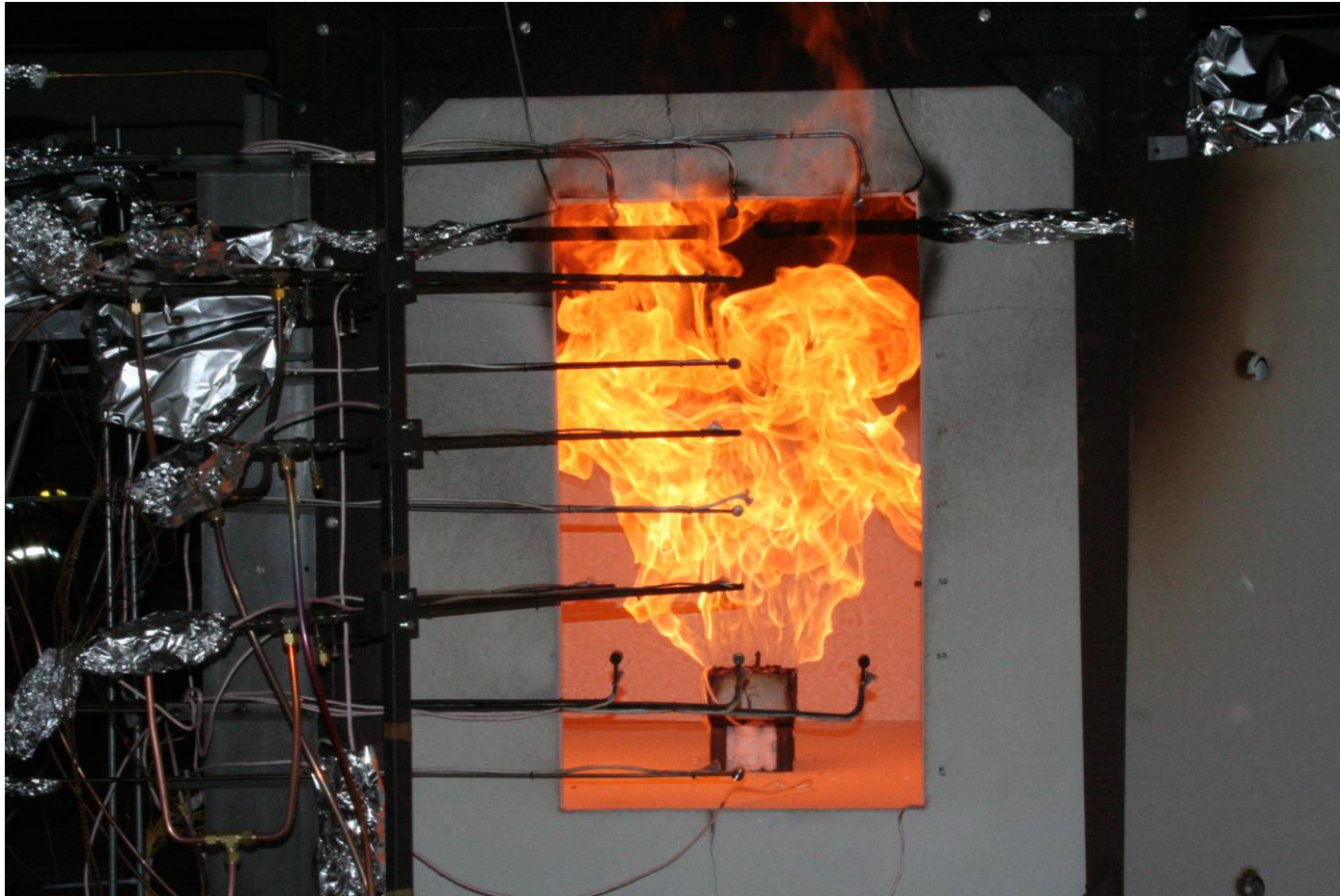
Liquid Fuel Burner



Results

- Utilized cooled (140 °C) gas sampling probes
- Designed cooled pool burner with thermocouples for height determination
- Improved gravimetric soot sampling method to allow up to 8 collections per 2 hour test
- Utilized total hydrocarbon analyzers to measure up to 50 % hydrocarbons as methane
- Continued development work on doorway optical soot probe
- Conducted 4 natural gas tests (4 fire sizes, 2 doorway widths)
- Conducted 2 heptane tests (3 fire sizes, 2 doorway widths)

180 kW Natural Gas Fire, Standard Doorway



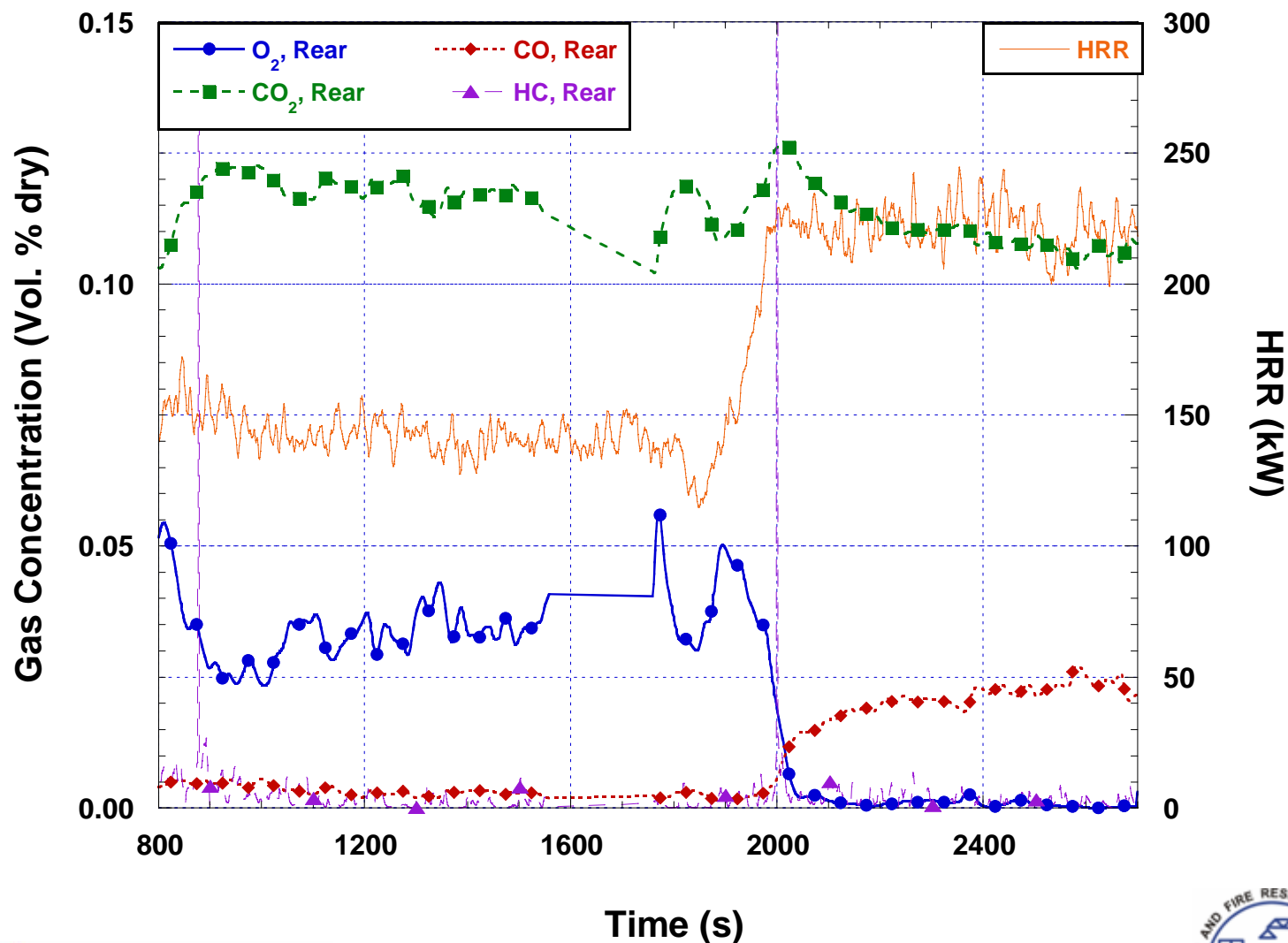
400 kW Natural Gas Fire, Standard Doorway



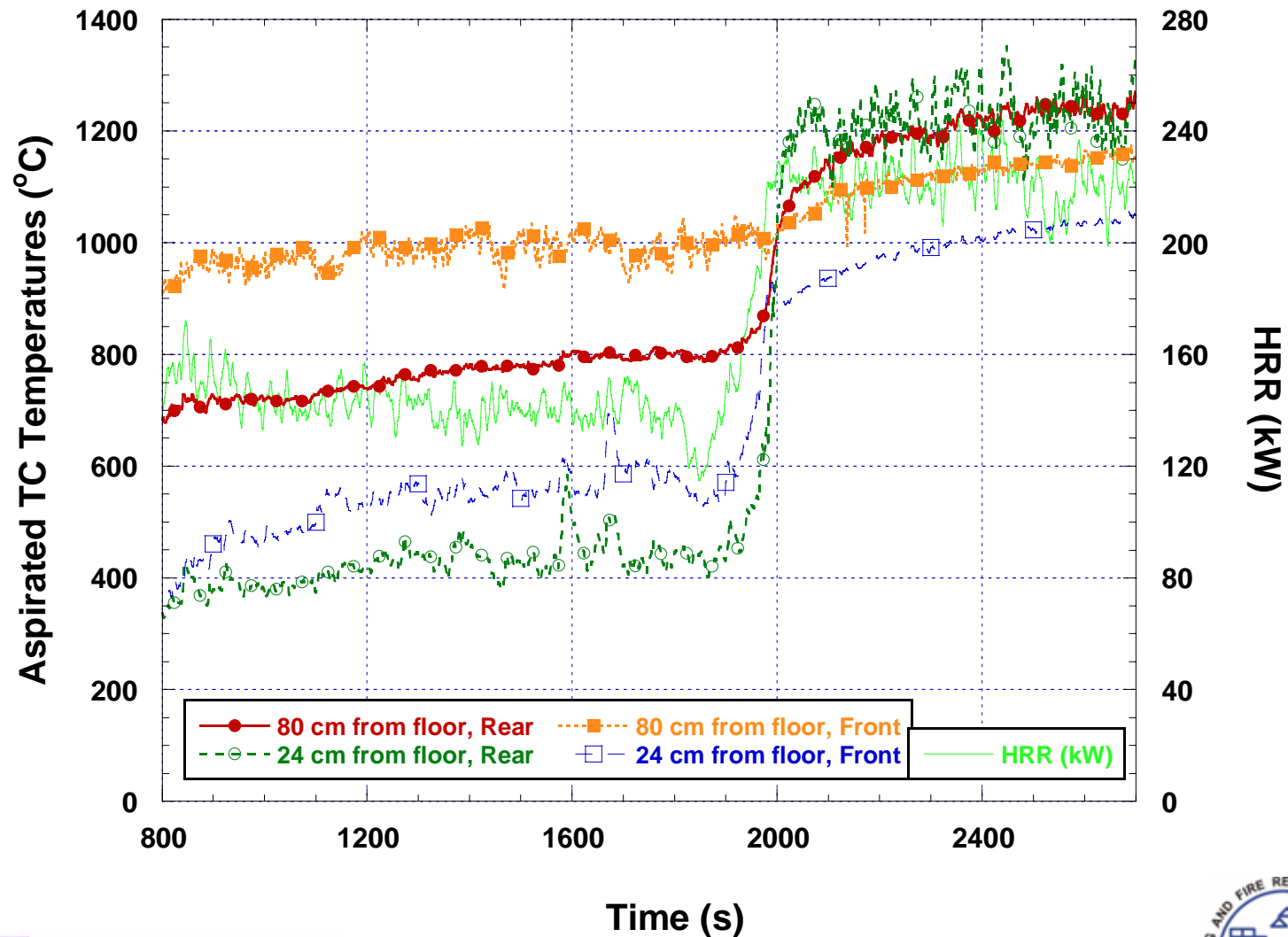
270 kW Heptane Fire, Standard Doorway



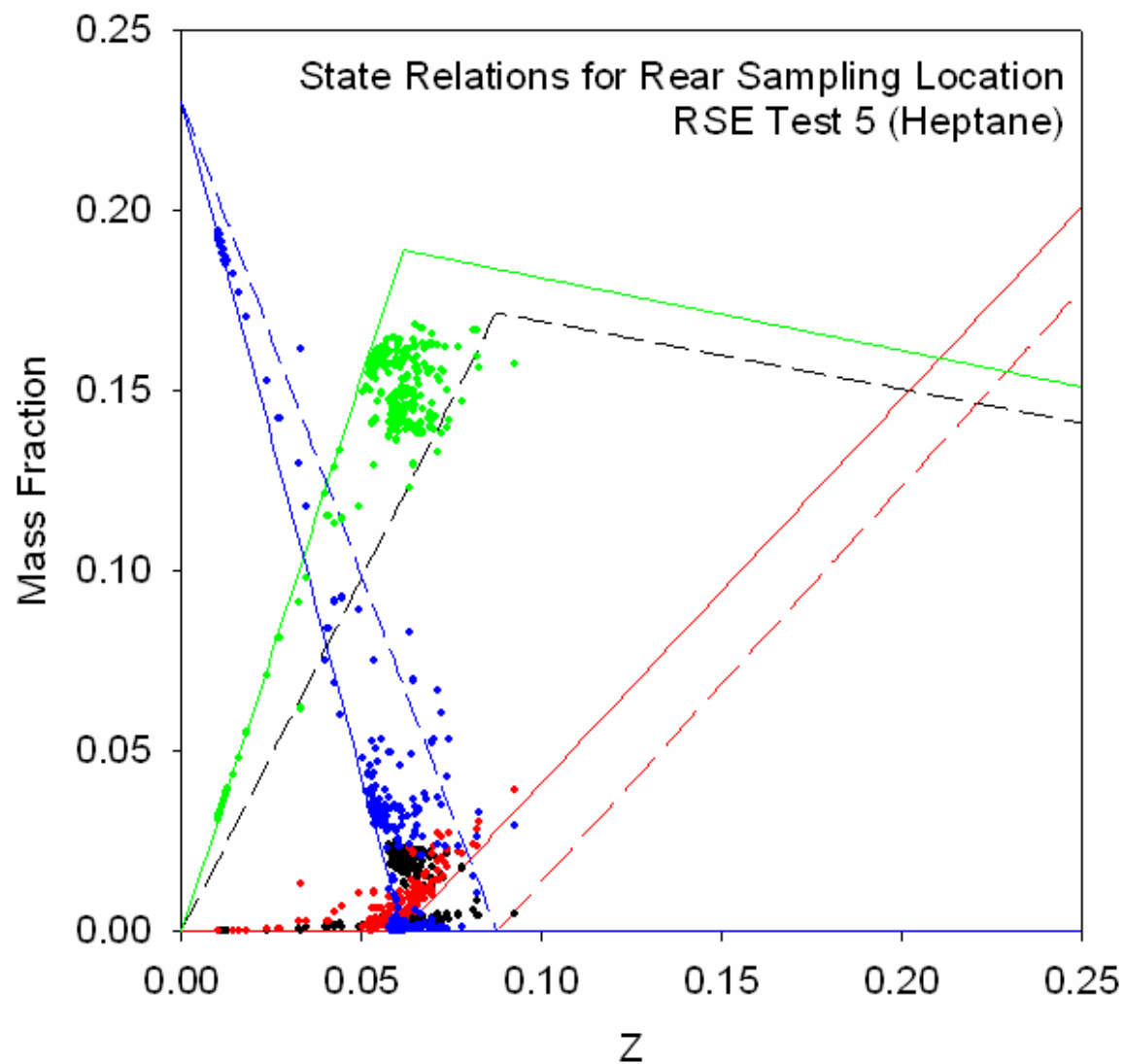
Rear Gas Concentrations and HRR for Heptane Fire, Std Door



Front and Rear Temperatures for Heptane Fire, Std Door



Mixture Fraction Plot of Heptane Fire, Std Door



225 kW Heptane Fire, Half-Width Doorway



225 kW Heptane Fire, Half-Width Doorway



Future Plans

- **Conduct Phase II experiments in June**
- **Complete analysis and report**
- **Implement measurement techniques in ISO9705 enclosure**
- **Continue to develop experimental database for enclosure fire dynamics understanding and model improvement/validation**